SPECIFICATION AMENDMENTS

Please amend that portion of the specification starting at line 8 on page 2 and ending at line 24 on page 20 as follows:

Prior arts for preventing this problem are disclosed in the Japanese Application Patent Laid-open Publication No. Sho 63-150465 (1988) and Hei 7-139455 (1995). These prior arts have an auxiliary injection valve and an electric heater installed in a bypass passage that bypasses the throttle valve in the intake air passage. The heater is energized at the time of a cold state of the engine to facilitate vaporization of the fuel. Hence no fuel adhesion is caused, and it prevents the combustion of the engine at start-up from deteriorating, and HC emission is reduced. In these prior arts, at the starting time of the engine, a throttle valve installed in the main air passage closes, and the bypass air control valve installed in the bypass passage (here, the cross area of the bypass passage is smaller than that of the main intake air passage) opens. Thereby the high-velocity airflow is generated in the bypass passage, and so atomization of the flowing fuel and vaporization of the fuel adhered onto the heater surface can be facilitated. Further, no heater is installed in the main air passage. Accordingly the resistance of the airflow passage at high velocity becomes lower, and the fall of engine power can be also prevented.

In an ordinary multi-point injection (MPI) system, liquid fuel is injected atomizing by a fuel injection valve installed near the intake port of each engine cylinder. The injected fuel

mostly adheres onto the intake passage wall, the intake valve and the cylinder wall. The fuel adhesion onto these walls causes to decrease the fuel amount to be supplied in a gaseous phase around the ignition plug. Hence, the ignitability and combustibility are deteriorated. On the contrary, with a system where fuel is heated and vaporized by a heater and then supplied to the cylinder, it is generally known that, because no fuel adheres onto walls, the ignitability and combustibility improve remarkably, particularly at the time of the cold state of engine, and so unburnt vaporized (HC) emission reduces.

An example starting apparatus of a conventional internal combustion engine is explained hereunder, using Fig. 9. The intake passage of the internal combustion engine comprising:

a main air passage 3, that consists of a intake passage 1, a surge tank 2, and a manifold passage 3a branched downstream of the surge tank 2 and connected to the intake ports 10 of respective cylinder (Fig.9 shows one pipe among the manifold 3a),

a bypass air passage 4 installed in parallel to the main air passage 3 and connected close to the intake port of each cylinder,

fuel injection valves 5 installed near the intake ports of respective cylinders or installed directly in the respective cylinders,

an auxiliary fuel injection valve 6 installed in the bypass air passage 4, and a bypass air control valve 7 capable of adjusting the incoming air quantity into the bypass air passage. ~~And a~~ A throttle valve 8 is installed in the intake passage 1 and an air cleaner 9 is installed upstream of the throttle valve8.

Besides, a heater 15 is provided to heat and vaporize the fuel injected from the auxiliary injection valve 6.

SUMMARY OF THE INVENTION

(Problems to be solved by the Invention)

With the construction shown in Fig. 9, when the engine is made start by using auxiliary injection valve 6, even if the throttle valve 8 in the intake passage 1 is closed from the beginning of start-up cranking, the air of the main air passage remains in the surge tank 2 and the manifold 3a in the downstream of the throttle valve 8. The remaining air flows into the cylinder 13, as shown in Fig.10 (c), for some period of time after the beginning of start-up cranking. The intake air quantity flowing into the engine at the time of start-up cranking is almost constant under a specified engine speed. Therefore the incoming air quantity from the bypass passage 4 to the engine decreases, as shown by a solid line in Fig. 10 (d), because the air flows into the engine from the main passage 3 for a while. A dotted line in Fig. 10 (d) represents the incoming air quantity from the bypass passage 4 to the engine in the case that no air flows in from the main passage 3.

The air velocity at the heater position and the variation of fuel vaporization ratio fuel are explained hereunder, making reference to Fig. 11 and Fig. 12.

When the air velocity at the heater position increases, the fuel vaporization increases as shown in Fig. 11, and when the air velocity at the heater surface increases in the intake stroke, the fuel vaporization ratio increases as shown in Fig. 12. When the incoming air quantity from the bypass passage 4 decreases as

shown by a solid line in Fig. 10 (d), the vaporization ratio of fuel adhered onto the heater 15 decreases as the air velocity at the heater position decreases.

Even if energization of the heater 15 and fuel injection from the auxiliary injection valve 6 are begun immediately after the beginning of start-up cranking shown in Fig. 10 (e) and (f), neither vaporization of the fuel adhered onto the heater 15 nor atomization of the fuel injected is facilitated. Because the air velocity in the bypass passage 4 (on the heater surface) decreases in the beginning of cranking explained above, and incoming vaporized fuel flow into the cylinder 13 is delayed as a result of decreased air velocity in the bypass passage 4. Consequently, the incoming fuel into the cylinder 13 decreases as shown by a solid line in Fig. 10 (g). Because of the above, there arises a problem that the time required from the beginning of cranking up to ignition and complete explosion becomes longer and so the startability deteriorates.

In addition, there arises another problem that, because the start of incoming fuel into the cylinder delays and ignition delays, the amount of unburnt vaporized (HC) emitted until the ignition increases as shown by a shaded area in Fig. 10 (g). A dotted line in Fig. 10 (g) represents the incoming fuel into the cylinder in the case that no air flows in from the main passage 3. Complete combustion herein means a timing that the engine speed after cranking and ignition reaches a stable idling speed (800 r/min, for example)

In short, with the above prior arts, because the remaining air of the surge tank and the manifold in the downstream of

throttle valve in the main air passage flows into the engine cylinder for some period of time after the beginning of start-up cranking, even if the throttle valve in the main passage is closed at the time of start-up, the incoming air quantity from the bypass passage decreases for a while. ~~And~~ Since neither atomization of the fuel injected from the auxiliary injection valve nor vaporization of the fuel adhered onto the heater is facilitated, fuel supply into the cylinder is delayed as a result of decreased air velocity in the bypass passage. Consequently the start-up time required from the beginning of start-up cranking up to complete explosion becomes longer and so the startability of the engine deteriorates. In addition, there arises another problem that, because the start of fuel quantity supplied to the cylinder delays and ignition delays, the amount of unburnt vaporized (HC) emitted until the ignition increases.

An object of the present invention, which has been made in view of the above problems, is to improve the startability of a system in which fuel is heated and vaporized by a heater at the start-up and then supplied to the cylinder. ~~That~~ Another object is to provide a staring apparatus and a starting method of an internal combustion engine so as to improve the startability and reduce the HC emission at the start-up of the engine. ~~And that~~ Another object is to provide a control method of an internal combustion engine so as to be able to satisfy the startability and improve the fuel efficiency drastically when applied to an idling stop system. ~~Further that~~ A further object is to provide an exhaust filtration apparatus of an internal combustion engine equipped with the above starting apparatus, with which HC

absorbent can be disused or the amount of HC absorbent to be held can be reduced, deterioration of the filtration performance can be prevented or minimized, and simple construction becomes available so as to be able to simplify the car layout.

(Means for Solving the Problems)

In order to solve the above problems, the first starting apparatus of an internal combustion engine of the present invention comprises a main air passage, bypass air passage provided in parallel to the main air passage and connected close to the intake port of each cylinder, a vaporization fuel supply means for supplying vaporized fuel to the bypass air passage, and a bypass air control valve capable of controlling the incoming air quantity into the bypass air passage,

wherein main air control valves for the main air passage are provided near intake ports in respective pipes of the intake manifold. Besides, the second starting apparatus of an internal combustion engine of the present invention is made according to the first starting apparatus above, wherein the bypass air control valve is opened at the time of start-up cranking of a starter motor, the main air passage is closed by the main air control valves, and vaporized fuel is supplied to the bypass air passage by the vaporization fuel supply means.

With the starting apparatus of an internal combustion engine of the present invention constructed as above, because the main air passage is throttled or closed at the time of start-up cranking and air flow into the bypass air passage is speeded up, the vaporization of fuel by the heater is immediately facilitated. Besides, because the air velocity in the bypass air

passage increases, the vaporization fuel flows into the cylinder speedily and supplied to the cylinder quickly. Because of the above, ignition is achieved speedily and the start-up time required up to complete explosion can be reduced remarkably, and hence the startability can be improved and the amount of unburnt vaporized can be reduced.

The third starting apparatus of an internal combustion engine of the present invention comprises a main air passage, a bypass air passage provided in parallel to the main air passage and connected close to the intake port of each cylinder, a bypass air control valve that is capable of controlling the incoming air quantity into the bypass air passage and opened at the time of start-up cranking, a vaporization fuel supply means for supplying vaporized fuel to the bypass air passage, and

fuel injection valves that are installed near respective intake ports of cylinders of the engine or installed directly in respective cylinders, and inject the maximum fuel quantity of themselves available in the cranking period within a specified length of time after the beginning of start-up cranking, and then decreases the injected fuel quantity or stops injection in the rest of the cranking period after injecting the maximum fuel quantity.

With the starting apparatus of an internal combustion engine of the present invention constructed as above, the bypass air control valve is opened at the time of start-up cranking so as to supply vaporized fuel to the bypass air passage. The maximum fuel of the starting injected from the fuel injection valve is done within, for example, 0.4 second after the beginning of

start-up cranking, and then the injected fuel quantity is decreased or injection is stopped. Thereby not only the start-up time can be reduced so as to improve the startability but also the fuel efficiency can be reduced and the amount of unburnt vaporized in exhaust can be reduced.

In the fourth starting apparatus, as a preferable mode of a starting apparatus of an internal combustion engine of the present invention, the vaporization fuel supply means comprises an auxiliary fuel injection valve and heater for heating the fuel injected from the auxiliary fuel injection valve. With this construction, because the fuel injected from the auxiliary fuel injection valve is heated and vaporized by the heater, supplied as vaporized fuel to the bypass air passage, and then taken into each cylinder, no fuel adheres onto the walls and so the start-up time reduces and the startability improves.

The starting method of an internal combustion engine of the present invention comprises a main air passage, fuel injection valves that are installed near respective intake ports of cylinders of the engine or installed directly in respective cylinders, a bypass air passage provided in parallel to the main air passage and connected close to the intake port of each cylinder, a vaporization fuel supply means for supplying vaporized fuel to the bypass air passage, and a bypass air control valve capable of controlling the incoming air quantity into the bypass air passage,

wherein at the time of start-up cranking, the bypass air control valve is opened and vaporized fuel is supplied to the bypass air passage from the vaporization fuel supply means, and

~~besides~~ the fuel injection valves inject the maximum fuel quantity of themselves available in the cranking period within a specified time after the beginning of start-up cranking, and a time for decreasing the injected fuel quantity or stopping the injection is set in the rest of the cranking period after injecting the maximum fuel quantity.

With the starting method of an internal combustion engine of the present invention constructed as above, because the injected fuel is supplied to the bypass air passage during start-up cranking and also additional injection from each fuel injection valve is performed at the beginning of the cranking period, the start-up time from start-up cranking up to complete explosion can reduce and the startability can improve. Besides, because the injection quantity from the fuel injection valve is decreased or injection is stopped in the rest of the cranking period after injecting the maximum injection quantity from the fuel injection valve, the startability can be improved and the amount of unburned vaporized including HC and CO in exhaust can be prevented from increasing.

The control method of an internal combustion engine of the present invention is that of an internal combustion engine equipped with any one of the first to fourth starting apparatus above, wherein the internal combustion engine is stopped automatically when a specified idling stop permissible conditions are satisfied, the bypass air control valve is opened and the start-up cranking is actuated by energizing the starter motor when a specified engine start conditions are satisfied after the engine has stopped by satisfaction of the specified idling stop

permissible conditions , and the vaporized fuel is supplied to the bypass air passage from the vaporization fuel supply means during start-up cranking.

With the control method of an internal combustion engine of the present invention constructed as above, because the air velocity in the bypass passage is high when the bypass air control valve is opened, the fuel vaporization is facilitated and high startability can be maintained. And because the vaporization fuel is supplied and accordingly no fuel adheres onto the intake passage wall or the cylinder wall, the fuel amount supplied at start-up can be reduced and the fuel efficiency can be improved remarkably. For this reason, the control method is very much suitable to an idling stop system.

Another mode of the control method of an internal combustion engine of the present invention is that of an internal combustion engine equipped with the fourth starting apparatus, wherein the internal combustion engine is stopped automatically when the specified idling stop permissible conditions are satisfied, the heater is energized for a specified time when the specified heater energization conditions are satisfied, after that, a non-energization period of the heater is set, and also start-up cranking is actuated by energizing the starter motor when a specified engine start conditions are satisfied after the internal combustion engine has stopped by the satisfaction of the idling stop permissible conditions, and vaporized fuel is supplied to the bypass air passage from the vaporization fuel supply means during start-up cranking.

With the control method of an internal combustion engine of

the present invention constructed as above, because the heater is energized for a specified length of time to increase the heater temperature so that the vaporization of fuel can be achieved quickly at the next start-up, the startability improves. Besides, because another period for stopping energization of the heater is provided, the power consumption of the heater can be reduced. For this reason, the control method is very much suitable to an idling stop system.

The exhaust filtration apparatus of the present invention, installed in an exhaust pipe of an internal combustion engine equipped with any one of the first to the fourth starting ~~apparatuses. It consists~~ apparatuses, consists of catalyst such as a catalytic converter rhodium that is made so as to hold no HC absorbent. With this construction, because unburnt vaporized emission from the starting apparatus of an internal combustion engine can be reduced, the exhaust filtration apparatus can be made only of catalyst such as catalytic converter rhodium and so the construction can be simplified and layout freedom of a car can be improved. Besides, deterioration of the filtration performance of the exhaust filtration apparatus can be prevented or minimized.

Another mode of the exhaust filtration apparatus of the present invention, installed in an exhaust pipe of an internal combustion engine equipped with any one of the first to the fourth starting apparatus, has one or more support containers on the exhaust pipe and the catalyst supports filled into one of the support containers hold HC absorbent. With this construction, because the filtration becomes possible by using HC absorbent

that is held on the catalyst supports to be filled in one support container, the construction can be simplified and layout freedom of a car can be improved.

Another mode of the exhaust filtration apparatus of the present invention, installed in an exhaust tube of an internal combustion engine equipped with any one of the first to fourth starting apparatuses, has plural support containers in the exhaust pipe, and the catalyst supports filled into any one of the support containers, that are located in the downstream of the exhaust pipe compared to the support container located in most upstream of the same, hold HC absorbents. With this construction, because HC absorbents are located downstream, its deterioration due to high temperature can be prevented and increase of HC emission can be controlled.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a structural drawing of main components showing the first embodiment of the starting apparatus of an internal combustion engine according to the present invention. Fig. 2 is a timing chart showing the starting method of the starting apparatus shown in Fig. 1. Fig. 3 is a Timing chart showing the starting method of the second embodiment of the starting apparatus of an internal combustion engine according to the present invention. Fig. 4 is a Detailed timing chart of the starting method shown in Fig. 3. Fig. 5 is a structural drawing of main components showing the third embodiment of the starting apparatus of an internal combustion engine according to the present invention. Fig. 6 is a structural drawing of main

components showing the exhaust filtration apparatus, using HC absorbent, according to the present invention. Fig. 7 is a timing chart of the present invention when applied to an idling stop system. Fig. 8 is a control flowchart in the idling stop system shown in Fig. 7. Fig. 9 is a structural drawing of main components showing a conventional starting apparatus of an internal combustion engine. Fig. 10 is a timing chart showing a conventional starting method of the starting apparatus shown in Fig. 9. Fig. 11 is a chart showing the fuel vaporization characteristic that varies by the air velocity at heater. Fig. 12 is chart showing the relationship between air velocity and fuel vaporization ratio in the intake stroke.

DETAILED DESCRIPTION OF THE INVENTION

(Description of the Preferred Embodiments)

An embodiment of the starting apparatus of an internal combustion engine of the present invention is described hereunder, using figures. Fig. 1 is a structural drawing of main components showing the structure of the intake passage of the starting apparatus of an internal combustion engine of this embodiment. An air cleaner 9 is located in the upstream of the intake passage 1, and a throttle valve 8 is located downstream. The intake passage equipped with the throttle valve, a surge tank 2, and a manifold 3a, that is branched downstream of the surge tank and connected to the intake port 10 of each cylinder, are called the main air passage (hereinafter called main passage) 3.

A fuel injection valve (hereinafter called port injection

valve) 5 that atomizes and supplies liquid fuel such as vaporizedoline and alcohol is installed near the intake port 10 of each cylinder of the engine.

On the other hand, a bypass air passage (hereinafter called bypass passage) 4 is provided in parallel to the main passage 3. The bypass passage 4 is branched on the way (Fig.1 and Fig.9 shows one element among the branched bypass passage) and connected close to the intake port 10 of each cylinder. In the bypass passage 4, a bypass air control valve 7, an auxiliary fuel injection valve (hereinafter called auxiliary injection valve) 6 and heater 15 for heating and vaporizing the fuel injected from the auxiliary injection valve 6 are installed. The bypass air control valve 7 may be an ON/OFF control valve capably of only fully opening/fully closing.

The heater 15 comprises a PTC heater (Positive Temperature Heater) or the like made of ceramic. It is possible to be heat up instantly by energizing so as to vaporize the fuel. The heater 15 may be flat plate type, cylindrical type, or grid type.

[0028]

A heater relay 12 controls to energizing/non-energizing of the heater 15 and a battery 11 is the power source of the heater 15. Each injection valves ~~15 and 16~~ 5 and 6, the bypass air control valve 7 and the heater relay 12 are controlled by a controller 14. There is also provided a starter motor (not shown) for start-up cranking. At the start-up, the starter motor gets energized by the driver's switching operation or by a starter control means such as the controller 14.

When fuel is heated and vaporized by the heater 15 and then supplied to each cylinder 13, the throttle valve 8 is closed and air is let into the bypass passage 4. The cross area of the bypass passage area is smaller than that of the intake passage 1 so that high velocity air flow is generated in the bypass ~~passage 4. And so~~ passage 4, and, thereby vaporization of the fuel adhered onto the heater 15 surface and atomization of the injected fuel are facilitated. Because no heater is installed in the main passage 3, this construction has an advantage that the airflow resistance of the main passage at high velocity is lower and so the engine power reduction can be prevented.